

REMARKS

Claims 1-13 are cancelled in favor of added claims 14-26 to eliminate reference numerals and multiple dependency and to otherwise conform to preferred U.S. format. No new matter is added. Entry of this Preliminary Amendment is in order, and an early and favorable first action on the merits is respectfully requested.

To the extent necessary, Applicant hereby request any required extension of time not otherwise requested and hereby authorizes the Commissioner to charge any prescribed fee not otherwise provided for, including application processing, extension, and extra claims fees, to Deposit Account No. 25-0120.

Respectfully submitted,

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APPENDIX

Attached is a substitute specification, together with a marked-up copy showing the changes made.



**Exhaust line and motive power unit comprising same**

**FIELD OF THE INVENTION**

The present invention relates to an exhaust pipe and also to a motive power unit comprising a heat engine at the outlet of 5 which a depollution device is provided, such an exhaust pipe being provided between the heat engine and the catalytic purification device.

**BACKGROUND OF THE INVENTION**

In order to satisfy the requirements laid down for the 10 preservation of the environment, motor vehicles powered by a heat engine are commonly equipped with a catalytic depollution device on the exhaust line. The active elements used in the catalytic depollution device operate satisfactorily only at a temperature much higher than the atmospheric temperature. This 15 operating temperature is from 300°C to 1000°C.

The catalytic depollution device is brought up to temperature and maintained at temperature by the circulation of the hot exhaust gases coming from the engine.

When the engine is started, after the vehicle has been 20 immobilised for a long period, the depollution device is not immediately efficient, and its temperature increases regularly as the exhaust gases circulate.

In order to enable the depollution device to reach its 25 normal operating temperature as quickly as possible, it is located as close to the engine as possible. Thus, the engine and the depollution device are often separated only by the exhaust manifold, the depollution device being located immediately at the outlet of that manifold.

However, even though the depollution device is located near the engine, the depollution device reaches its normal operating temperature only after a relatively long lapse period of time, in the course of which the exhaust gases are not 5 correctly treated by the depollution device.

SUMMARY OF THE INVENTION

The object of the invention is to propose a solution for reducing the time during which the depollution device is inefficient.

10 To that end, the invention relates to an exhaust pipe comprising a thin metal tube having a wall thickness of less than 1 mm, which tube comprises, over at least a portion of its length, a peripheral sheath formed from a thermally expandable material.

15 According to particular embodiments, the exhaust pipe comprises one or more of the following features:

- the thermally expandable peripheral sheath has a thickness of from 0.5 mm to 20 mm and preferably from 2 mm to 15 mm;

20 - the thermally expandable material is composed of refractory ceramic fibres, of vermiculite and of an organic binder;

25 - at the normal operating temperature of the exhaust pipe, the thermally expandable peripheral sheath has a density substantially equal to 1;

- it comprises a thermally insulating layer interposed between the thin tube and the thermally expandable peripheral sheath;

- the thermally insulating layer comprises long polycrystalline ceramic fibres;

5 - the thickness of the thermally expandable peripheral sheath is greater than 70% of the cumulative thicknesses of the thermally insulating sheath and the thermally expandable peripheral sheath;

- it comprises an external casing for holding the thermally expandable peripheral sheath; and

10 - the thermally expandable peripheral sheath comprises two unconnected sleeves, these two unconnected sleeves being surrounded by the same external peripheral casing extending from the one to the other along the thin tube, a space filled with air thus being delimited, between the two unconnected sleeves of peripheral sheath, by the thin tube and the casing.

15 The invention relates also to a manifold comprising several convergent exhaust pipes such as defined above.

20 Finally, the invention relates to a motive power unit comprising a heat engine, an exhaust line comprising at least one catalytic depollution device, characterized in that the portion of the exhaust line between the engine and the catalytic purification device comprises at least one exhaust pipe or a manifold such as are defined above.

#### BRIEF DESCRIPTION OF THE DRAWINGS

25 The invention will be better understood on reading the following description which is given purely by way of example and with reference to the drawings in which:

- Figure 1 is a diagrammatic view of a motive power unit of a motor vehicle;

- Figure 2 is a cross-sectional view of the manifold of the motive power unit in Figure 1;
- Figure 3 is a longitudinal section through the manifold of Figure 2;
- 5 - Figure 4 is a cross-section through a single exhaust pipe according to the invention;
- Figures 5 and 6 are views identical to those of Figures 2 and 3, respectively, of a variant of a manifold according to the invention; and
- 10 - Figure 7 is a view in longitudinal section of an exhaust pipe according to yet another variant of the invention.

#### DETAILED DESCRIPTION

Figure 1 shows a geared motor unit of a motor vehicle. This geared motor unit comprises an engine 12 to the outlet of 15 which an exhaust line 14 is connected.

The engine 12 is a heat engine, such as an internal combustion engine or a diesel engine. In the example considered, the engine is a four-cylinder engine which therefore has four exhaust outlets. The exhaust line 14 is 20 equipped with a first catalytic purification device 12. This catalytic purification device comprises, for example, a porous substrate through which the exhaust gases pass, the substrate being covered with precious metals. The normal operating temperature of the catalytic purification device is from 300°C 25 to 1000°C.

The exhaust line comprises an exhaust manifold 18 between the four outlets of the engine 12 and the first catalytic purification device 16.

Finally, the exhaust line comprises a pipe 20 for evacuating the exhaust gases, which pipe 20 is connected to the outlet of the catalytic purification device 16. The evacuation pipe 20 opens out to the atmosphere. A second catalytic 5 purification device 22 is located in the linear portion of the evacuation pipe 20. As is known *per se*, the pipe 20 may also be equipped with other catalytic purification devices and/or with particle filters.

The manifold 18 comprises four separate pipes 18A, 18B, 10 18C, 18D which are connected to each other by one end where they converge to form a common pipe 24. This common pipe is connected at its free end to the inlet of the catalytic purification device 16. The manifold 18 has a flange for securing to the four exhaust outlets of the engine. This 15 flange is located at the ends of the four pipes of the manifold in order to ensure that they are connected to the corresponding outlets of the engine.

Each exhaust pipe 18A, 18B, 18C, 18D of the manifold comprises, as illustrated in Figures 2 and 3, four thin-walled 20 metal tubes 26A, 26B, 26C, 26D. The metal tubes have a wall thickness of less than 1 mm. This thickness is advantageously less than 0.5 mm and is preferably from 0.2 mm to 0.4 mm.

A peripheral sheath 30 formed from a thermally expandable material extends around each tube over at least a portion of 25 the length thereof. Advantageously, the sheath extends over the entire length of the pipes. The thermally expandable sheath is surrounded by an outer casing 32 for holding the sheath 30 around the tubes.

As illustrated in Figure 2, in the region where the four 30 thin tubes of the four convergent pipes are adjacent to each

other, the material forming the thermally expandable sheath 30 is received in a common casing 32 surrounding the four tubes.

Advantageously, this casing 32 is formed by two half-shells 32A, 32B which are connected to each other along two longitudinal joints extending along the length of the pipes. 5 For their connection, the two half-shells comprise an outer longitudinal flange along which these two half-shells are placed side by side.

10 The thermally expandable material forming the peripheral sheath and surrounding the tubes is sometimes referred to as an "intumescent material".

15 A material of that type is such that, when the temperature rises, the volume of the material increases significantly. In the case in point, when the temperature increases, the material is placed against the outer wall of the thin tubes, thus stiffening them.

20 For example, the thermally expandable material is composed of refractory ceramic fibres, [[of]] vermiculite, and [[of]] an organic binder, especially latex, thus ensuring the cohesion of the thermally expandable material. Vermiculite has the property of expanding when the temperature increases.

25 That type of material can withstand temperatures of up to 850°C. Such materials are marketed in layer form, in particular, by the company 3M under the references INTERAM 100/200/550, and by the company UNIFRAX under the references XPEAV2 and AV2i.

The thickness of the thermally expandable sheath surrounding each thin tube is from 0.5 mm to 20 mm. Preferably, this thickness is from 2 mm to 15 mm.

The amount of thermally expandable material disposed between the thin tubes and the casing is selected in such a manner that the sheath has, in the space thus delimited and at the temperature of use envisaged, an average density of 5 approximately 1. This average density is often referred to by the acronym "GBD", which stands for Gap Bulk Density.

According to the first embodiment of the invention and as illustrated in Figure 4, the pipe 20, at least upstream of the second catalyst 22, is formed by a thin tube 34 which has a thickness of less than 0.5 mm and which is surrounded by a 10 thermally expandable peripheral sheath 36 such as described above. A casing marked 38 and formed by a tube surrounds the sheath 36.

By way of variation, the evacuation pipe 20 is formed by a 15 metal tube which has a thickness greater than 5 mm and which is not covered by a thermally expandable sheath, only the manifold 18 located between the engine 12 and the catalytic purification device having the structure described above.

In order to manufacture such an exhaust pipe, and in 20 accordance with a first method, the thin tube is introduced into the external casing. They then together delimit an annular gap into which the thermally expandable material is injected by spraying using a device such as that described in the document EP 0 091 413.

By way of variation, the thermally expandable material is 25 in the form of a layer which is wrapped or non-wrapped. The layer is wound around the thin tube. The whole formed by the thin tube and the layer is introduced into the casing and is secured there by any appropriate means.

When an engine is started cold, the exhaust gases circulating in the exhaust line transfer heat energy for heating the walls of the exhaust pipes. Inasmuch as the walls of the tubes upstream of at least [[of]] the first catalytic 5 purification device have a reduced thickness, these walls rise in temperature very quickly, so that little heat energy coming from the exhaust gases is lost for heating the walls. Thus, the heat energy conveyed by the exhaust gases is transported substantially as far as the catalytic purification device and 10 enables the temperature thereof to be increased very rapidly.

In addition, during the heating of the walls, the thermally expandable material increases in volume and compresses the walls of the thin tubes. Therefore, the thin tubes are clamped at their periphery by the thermally 15 expandable material, thus increasing the general rigidity of the manifold, even though the rigidity inherent in each thin tube is low owing to their reduced thickness and their increased deformability caused by the elevated temperature.

Thus, with a manifold according to the invention[[,]] and, 20 more generally, with an exhaust pipe such as defined above, it is possible to very rapidly [[to]] transfer heat conveyed by exhaust gases to an item of equipment ~~that is~~ to be heated, without losing a substantial portion of the heat being conveyed by the exhaust gases ~~being dissipated to dissipation~~ through 25 the pipes, ~~owing due~~ to the small thickness of the thin tubes used.

~~What is more~~ Moreover, the proposed arrangement has a relatively low mass, while at the same time having sufficient rigidity for the applications considered.

30 Figures 5 and 6 show a variant of a manifold.

In this embodiment, elements that are identical or similar to those of the embodiment of Figures 2 and 3 are marked by the same reference numerals.

5 In this embodiment, a layer 40 of thermal insulation is interposed between the outer surface of the thin-walled tubes and the thermally expandable sheath 30. This sheath completely surrounds the thin tubes over their entire periphery. It is placed directly in contact with the outer surface of these thin tubes.

10 The thermally insulating layer is formed from long ceramic fibres. It is composed, for example, of polycrystalline fibres formed from mullite or aluminium aluminum oxide, these polycrystalline fibres optionally being held in place by a binder. Such a layer is adapted to withstand a temperature of 15 1200°C and provides thermal protection for the thermally expandable sheath. Such layers are marketed, for example, by the company SAFFIL under the references LDM and ECOFLEX 200, by the company IBIDEN under the reference FLEC N-2.3 or by the company UNIFRAX under the reference CCmax 4HP. In the example 20 considered, the thickness of the layer 40 is of the order of 2 mm, while the thickness of the thermally expandable sheath 30 is 8 mm. More generally, the thermally expandable layer extends advantageously over more than 70% of the cumulative thickness of the thermally expandable sheath and the thermally 25 insulating layer.

According to a variant illustrated in Figure 7, the thin tube marked 50 is surrounded by a sleeve 52A, 52B of thermally expandable material only at two unconnected portions of the tube. A casing 54 is arranged around the tube. This casing 30 extends from one sleeve of thermally expandable material to the other. Thus, a free space 56 is delimited between the casing

and the thin tube, between the two sleeves of thermally expandable material.

In this arrangement, the free space 56 delimited between the two sleeves 52A, 52B of thermally expandable material forms 5 thermal insulation which prevents the loss of heat energy to the outside.

**ABSTRACT**

An exhaust pipe includes a thin metal tube having a wall thickness of less than 1 mm and, over at least a portion of its length, a peripheral sheath formed from a thermally expandable material.